Generation of phonon lasing in a thermal quantum nanomachine

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It is well-established in the macroscopic world that a heat gradient can be used to generate power for example in a steam engine. We transfer this concept to the nano-world and discuss the possibility to generate lasing, as a prototype quantum mechanical phenomenon, by a heat gradient. We apply this concept to propose a nanomachine which is capable of realizing and maintaining an inversion. Our system consists of a central three-level system interacting with a two-level subunit at each side. Each two-level system is coupled to a heat bath. The different temperatures of the baths impose a heat gradient. For certain parameters, at the central quantum system, the flow could be accompanied by the coherent phonon lasing.

The phonon laser has been on the mind of numerous physicists in nanostructured solids or for nano-mechnical oscillators. Our unusual concept is fundamentally new and addresses a several communities. This concept of a phonon laser shows that a heat gradient in the nano-world can be used to generate coherent states.

In this contribution, we present a conceptionally new idea of a nanomachine driven by a heat gradient to generate phonon lasing. Our description of the system kinetics is based on the Lindblad form of a Quantum Master Equation and the coupling to the lattice displacement field is described via a semiclassical equation. Indeed, we show that the positive inversion can be harnessed to generate coherent optomechanical oscillations and phonon lasing in nanoscopic quantum systems (e.g. possible implementation in a˜system composed of semiconductor quantum dots).

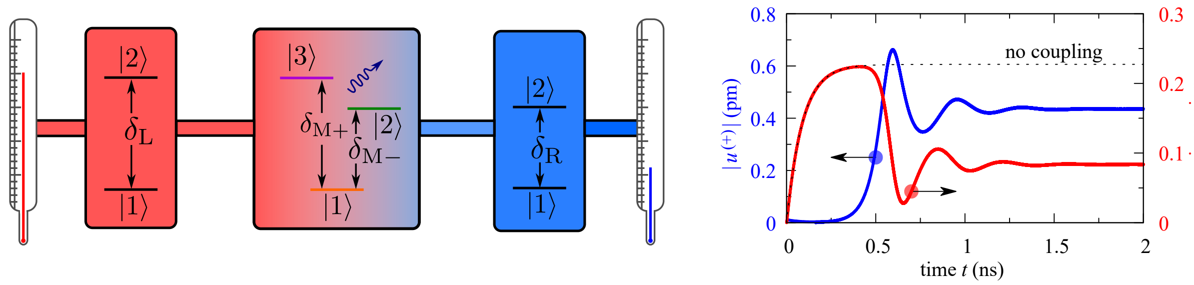

Figure 1: *Left:* Sketch of the system. *Right:* Time evolution of the inversion (red) and the amplitude of the lattice displacement field (blue).

[1] P. Karwat, D. E. Reiter, T. Kuhn, and O. Hess, *Phys. Rev.* A **98**, 053855 (2018).